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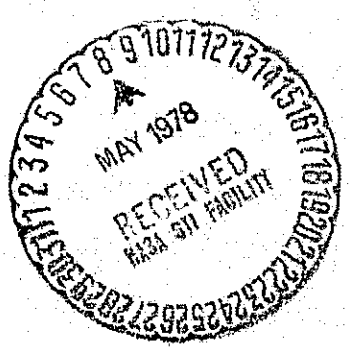
Thermal Power Systems
Small Power Systems Applications Project

Proceedings of Small Power Systems Solar Electric Workshop

Held at Aspen, Colorado
October 10—12, 1977

Volume I. Executive Summary



Prepared for
Department of Energy
by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California
(JPL PUBLICATION 78-10)

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Volume I. Executive Summary

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February 1978

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ABSTRACT

This Executive Summary describes the background, objectives and methodology used for the Small Power Systems Solar Electric Workshop, held October 10 - 12, 1977, in Aspen, Colorado, and presents a summary of the results and conclusions developed at the workshop regarding small solar thermal electric power systems.

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Introduction 1.0

1.1 BACKGROUND

The Department of Energy is responsible for developing the technology that will be suitable for providing low-cost, long-life, reliable power systems for use in a wide range of applications. The emphasis is on developing technologies that, when put into service, will reduce the need for scarce fossil fuels. Therefore, the Solar Thermal Power Office of the Division of Solar Technology of the Department of Energy has established electric power technology programs in three primary areas:

- o Central power applications
- o Dispersed power applications
- o Advanced technology.

The Small Power Systems Program is being managed as part of the Department of Energy dispersed power applications activity; the Program Technical Manager is the Jet Propulsion Laboratory. Within this program, the Small Power Systems Solar Electric Workshop was one of the early activities designed to support initial definition of program requirements. The program recognizes that the electric utility industry will be a primary user. Input from the utility community, regarding their needs related to dispersed small generating equipment is therefore valuable in shaping the research and development program.

1.2 OBJECTIVES

The workshop was designed to accomplish four primary objectives:

- o To introduce utilities to small solar thermal power technology, its potential and the programs for its development
- o To pinpoint the issues involved in the adoption of small solar thermal power which will influence its development
- o To establish communication channels with utilities, which will assist the Jet Propulsion Laboratory in developing the technology in ways that will meet the needs of small utilities

- To gain input on how the Jet Propulsion Laboratory's upcoming Request for Proposal for experimental projects can be made attractive to various types of utilities, particularly the small electric utilities.

1.3 APPROACH

The purpose of the workshop was to establish an effective interchange of ideas and communication among electric utility representatives, the Department of Energy and the Jet Propulsion Laboratory. Therefore, the format for this workshop was designed to include:

- Formal presentations
- Panel discussions
- Small group interactive discussions
- Informal gatherings.

The workshop program showing the discussion topics and a list of participants is included at the end of this Executive Summary. Formal Proceedings were prepared to document comprehensively the presentations and dialogue at the workshop. The Proceedings are available through the United States Government Technical Information Center.

Workshop Program 2.0

MONDAY, OCTOBER 10, 1977

MORNING

Registration

Buffet Lunch

AFTERNOON

Technology and Program Overview

- Welcome and Introduction
  Robert R. Ferber, Workshop Chairman, Requirements Definition Task Manager, Small Power Systems Application Project, Jet Propulsion Laboratory
- Orientation to Workshop Goals
  Doug Kruschke, Staff, Energy Services Consulting
- Department of Energy Solar Thermal Programs
  James Rannels, Program Manager, Division of Solar Technology, Department of Energy
- History and Overview of Jet Propulsion Laboratory
  Roger Bourke, Assistant Section Manager for Solar, Systems Analysis Section, Jet Propulsion Laboratory
- Solar Thermal Power Technologies
  John E. Bigger, Project Manager, Solar Thermal Technology, Electric Power Research Institute
- Small Power Systems Applications Project Overview
  Alan T. Marriott, Technical Manager, Small Power Systems Applications Project, Jet Propulsion Laboratory
- Technologies for Small Power Systems Applications
  Robert R. Ferber, Requirements Definition Task Manager, Small Power Systems Applications Project, Jet Propulsion Laboratory
- Solar Power Research at Electric Power Research Institute
  John E. Bigger, Project Manager, (Solar Thermal Technology), Electric Power Research Institute

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- o Solar Power Research at Solar Energy Research Institute
  Charles J. Bishop, Senior Staff, Solar Energy Research Institute
- o The Southwest Project
  Kenneth Hogeland, Principal Engineer, Stone and Webster Engineering Corporation

EVENING

Informal Social Hour, The Gant

TUESDAY, OCTOBER 11, 1977

MORNING

Comparing Power Options (Panel Discussion)

MODERATOR:

Vincent C. Truscello, Manager, Solar Thermal Power Systems Projects, Jet Propulsion Laboratory

PANELISTS:

Merwin Brown, Manager of Research, Arizona Public Service Company

Frank Goodman, Resource Development Engineer, Los Angeles Department of Water and Power

Peter Steitz, Planning Engineer, Burns & McDonnell

Orientation for Workshop Discussion Sessions

Mike Van Horn, Project Manager, Energy Services Consulting

Solar Thermal Power: Institutional Issues

Overview Presentation

Robert L. Mauro, Director of Energy Research, American Public Power Association

Small Group Discussions

AFTERNOON

Environmental and Siting Issues

Overview Presentation

Edward J. McBride, Systems Engineer, Black & Veatch

Small Group Discussions

Financial Issues

Overview Presentation

Tifton Simmons, Jr., Vice President, Smith, Barney, Harris, Upham & Company

Large Group Discussion

EVENING

Dinner Presentations

Solar Architecture in the Aspen Area

Gregory Franta, Architect, Sundesigns

Energy Storage

Thomas R. Schneider, Project Manager, Electric Power Research Institute

WEDNESDAY, OCTOBER 12, 1977

MORNING

Workshop Sessions Orientation

Doug Kruschke, Staff, Energy Services Consulting

Sites for Experimental Solar Thermal Systems

Overview Presentation

Herbert J. Holbeck, Field Test Integration and Management Task Manager, Small Power Systems Applications Project, Jet Propulsion Laboratory

Small Group Discussions

Small Utility Planning

Overview Presentation

Peter Steitz, Planning Engineer, Burns & McDonnell

Thomas J. Kuehn, Commercialization Analysis Task Manager, Small Power Systems Applications Project, Jet Propulsion Laboratory

Large Group Discussion

AFTERNOON

Workshop Wrap-Up

Peter Klock, Project Director, Energy Services Consulting

Dave Evans, Staff, Energy Services Consulting

Doug Kruschke, Staff, Energy Services Consulting

Final Remarks and Workshop Closing

Robert R. Ferber, Workshop Chairman,
Requirements Definition Task Manager, Small Power Systems
Applications Project, Jet Propulsion Laboratory

Results and Conclusions 3.0

The results of the workshop take the form of the conclusions and statements formulated by the workshop participants, themselves, regarding the needs for, advantages of, and barriers to the development of small solar power-generating technology. To lay a foundation for the discussions leading to these conclusions, the first day of the workshop was largely spent in hearing overview presentations on the present status of solar technology. The presentations were followed by a panel discussion, presentations on pertinent issues and a series of small group discussions. The discussions were designed to expand and clarify the participants viewpoints on the issues. The results of the discussions are summarized in the following sections.

3.1 COMPARING POWER OPTIONS

When electric utility executives plan for future electric generating capacity, solar equipment is considered alongside other advanced and conventional types of energy conversion systems. The capital cost of solar equipment is presently high. Electric utility planners have many considerations when evaluating the purchase of solar electric generating equipment, particularly when compared to other, better known, types of proven power-generation equipment. In planning for the adoption of solar power systems, it is difficult to predict user's attitudes as they relate to purchase of high-cost and high-risk technologies.

A primary impediment to the practical implementation of solar power plants is the statistical variability of insolation. Plants of the future will require major equipment redundancy, employing conventional technology and/or large energy storage capacity. This requirement will increase the cost of solar electric power plants.

Once technical feasibility and reliability have been proven, solar equipment will most likely be implemented in hybrid power plants. The hybrid

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plants will contain some amount of conventional generating capacity using fossil fuels to generate electricity when the sun is not available. The need to save oil continually increases the attractiveness of solar energy as an option for generating electricity and tends to raise the acceptance risk level in planning decisions.

Retrofitting existing steam electric generating facilities to use a solar heat source is a near-term option for utilizing solar energy. However, several difficulties may be encountered, including the high cost of developing the solar steam electric generating equipment interface.

Decisions to utilize solar technology when a utility expands generation capacity will be strongly influenced by local economic, institutional and environmental considerations. However, each decision must also be made by acknowledging regional and national objectives. The Federal Government and the Department of Energy must clarify and communicate their objectives to assist utilities in making planning decisions that support regional and national objectives.

As scarce fossil fuels are consumed, attention must be directed toward choosing electric power options based on renewable energy sources. Solar energy is renewable and, therefore, should be developed.

3.2 INSTITUTIONAL ISSUES

Numerous institutional issues should be acknowledged when considering the adoption of solar power into the utility industry in the United States. These issues relate to viewpoints held by:

- Government developmental agencies
- Regulatory agencies
- Special interest groups
- Utilities
- Major power users
- Equipment manufacturers
- General public.

The overriding institutional issue relates to the public perception of opportunities for using solar technology to generate electric power. The public, currently, has unrealistically optimistic expectations regarding the cost and availability of solar electric power, largely due to the view presented in the mass media. This expectation could cause the public to distrust government and industry decision-makers, if it believes that solar development is advancing too slowly. This situation is further complicated by the fact that public opinions vary significantly according to geographical region. Government and industry decision-makers can avoid being forced into making premature decisions or avoid confrontations with an ill-informed public by participating in the solar development process. Such participation may take the form of educating the public regarding the real cost and benefits of solar thermal power, as well as a reasonable schedule for implementing the technology in a manner that will serve national interests.

The size of an electric utility company and whether or not it is publicly or privately owned has a direct effect on the level of risk acceptable in planning, developing and purchasing new equipment. In order for many utilities to actively participate in high-risk solar research, development and demonstration, they need to devise innovative schemes for increasing their flexibility in the planning process. When considering new generation capacity, the small utilities often band together to share ownership or pool power. This sharing may be in conjunction with larger electric utility operations. Consequently, the large and small utilities may see a way to combine efforts in a fashion mutually beneficial for the development of solar power.

The Department of Energy may speed acceptance of solar plants by finalizing solar-related siting regulations, thus firming up the planning basis for developers and utilities. As the major source of financing solar electric development, the Federal Government must commit to allocating suitable amounts of public funds.

Means must be developed to identify and coordinate the efforts and roles of all the groups involved in solar development. The Small Power Systems Solar Electric Workshop successfully initiated this process and now the participants, themselves, need to take the responsibility for carrying out the process.

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3.3 ENVIRONMENTAL AND SITING ISSUES

The selection of a site for a solar power plant is a critical step in the planning process, since it will characterize the availability and intensity of the energy source. In many ways, siting a solar power plant is similar to siting a conventional fossil-fueled plant; however, the specific requirements are noticeably different. One of the most obvious requirements unique to a solar plant is the need for large land areas to accommodate the solar collector system. Solar power plant siting factors include:

- Cooling water
- Land area
- Land contours
- Variability and intensity of insolation
- Seismic susceptibility
- Interface with existing utility systems
- Chemical and thermal pollution effects on the local ecosystem
- Potential for pumped hydro or other energy storage options
- Public safety
- Aesthetics
- Environmental impact.

Once the site is selected, site data must be collected and analyzed, prior to making a decision to allow construction to proceed. A decision to proceed with construction should be formulated on the basis of specific site information. Regional information, alone, will not be adequate, since plant requirements and effects depend significantly on the terrain, microclimate, and other factors associated with each site.

Solar thermal electric power generation offers several opportunities to utility, industrial and commercial companies that need flexibility in siting requirements. For example, modular solar thermal systems may be dispersed to serve major load centers in urban areas, such as food processing industries or shopping centers. On the other hand, modular solar thermal systems can be integrated in large-capacity electric power plants set in rural environments, where land is readily available.

When choosing between small power systems dispersed at urban sites near the load, and large integrated power plants sited in rural environments, numerous (and often intangible) factors should be considered. Some examples are:

- o Environmental impacts
- o Socio-economic effects
- o Competing land uses.

The public must be informed of the implications of rural versus urban power plant siting, since competition for land tends to increase in urban areas. As business and industrial growth increase, the need for power increases, and the availability of land for siting power plants decreases. Therefore, competing land use near a planned solar power plant should be acknowledged and assessed as part of site selection studies.

To facilitate siting of both urban and rural plants, the environmental regulations and licensing processes must be clearly defined by local and federal agencies. These regulations should include consideration of special applications, such as hybrid solar-fossil fuel power plants and distributed versus central receiver-type solar thermal systems.

Siting new power generating facilities within the constraints of future environmental, socio-economic and land use requirements is a difficult job. Public acceptance of planned power systems will also continue to be important when planning additional generation capacity. Siting regulations are particularly difficult to anticipate, in the case of solar thermal power, due to a lack of experience and established technical regulatory guidelines. Therefore, acceptance of solar thermal power plants will be facilitated when the pertinent guidelines are available for developers to use in planning for siting, construction and operation of solar thermal power plants.

3.4 FINANCIAL ISSUES

Solar thermal power is presently a high-risk, capital-intensive, long term investment. Due to the stiff competition with lower-risk investments for limited funds, new means of financing must be developed to assist utilities and industrial owners in planning to own and operate solar power plants. One

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of the first steps in improving the financial status of solar technology is to identify methods for assessing risk levels and evaluating their acceptability. Conventional financing institutions are unwilling and unable to accept the high risks currently associated with unproven advanced technology. Therefore, a new financing entity should be considered. Since solar research and development will receive no preferential treatment by private investment sources, support must come from groups actively involved in the development of solar electric power, such as:

- Federal Government agencies
- Solar equipment manufacturers
- Utilities.

The government will most likely fund the first few high-cost experimental and demonstration systems. In order to maximize capital recovery, these trial installations should be designed to be resold and incorporated permanently into the host utility system, after the trial period. The sell-back price would be determined by the system's performance capabilities and the cost of competitive generating equipment. The numerous differences in the financing capabilities of various types and sizes of utilities indicate that significant efforts and changes should be undertaken to provide the support, incentives and economic environment necessary for the development of solar technology.

The opportunities for financing solar electric power equipment and facilities will increase as a self-sustaining solar electric power industry develops. The long term stability of a solar industry will be enhanced when manufacturers and reputable design engineering firms can offer technically and economically feasible solar electric power systems. During the formation of a solar electric power industry, the financing status of solar technology would be greatly enhanced by a reduction in capital costs and a demonstration of equipment reliability. Therefore, effective and efficient research, in both the government and private sectors, should be continued to support the establishment of technology that can compete with conventional and other advanced small power system technology for generating electricity.

3.5 SITES FOR EXPERIMENTAL SOLAR THERMAL SYSTEMS

As part of the Small Power Systems Applications Project, the Jet Propulsion Laboratory intends to conduct several major experiments. These experiments include the erection of a small test system, operating in a host utility system. Formal action leading to the first of these experiments is expected to begin in mid-1978. During the workshop, the utility participants provided input on the design of the experiments, especially regarding the selection and role of the host utility in the first experiment. The major conclusions made at the workshop are summarized here.

The host-selection process should be carried out in two phases:

1) Preliminary qualifications statement
2) Formal Request for Proposal and proposal submission.

The experiments should be broadly designed to permit participation by many types and sizes of utilities. The selection procedure should, therefore, recognize the differences in financial and manpower resources between large and small utilities and attempt to compensate accordingly. Once the necessary requirements have been defined, a preliminary qualifications statement should be issued which clearly delineates the responsibilities of the host utility and the Jet Propulsion Laboratory. This process will provide an opportunity for a large cross-section of utilities to analyze their level of interest in, and potential for, future participation in the experiment without preparing a costly formal proposal. The results of the process will aid the Jet Propulsion Laboratory in identifying interested and capable utility companies that are reasonable candidates for responding to a detailed Request for Proposal. The process will also save time and money in expediting the experiment itself. Having identified the candidate utilities, a formal Request for Proposal must be distributed. This Request for Proposal may contain descriptions of:

- The complete scope and schedule of the experiment
- The role and responsibilities of the Jet Propulsion Laboratory and the host utility
- The proposal evaluation criteria and process
- The environmental, resource and operational requirements of the experimental system
- Possible sell-back arrangements for the experimental hardware at the completion of the testing period.

The host utility should have currently installed generating capacity in order that it will be able to monitor the performance of the test solar facility properly. In addition, the provision of land and preparation of the test site should fall under the responsibilities of the host utility. However, the actual construction of the solar power plant should be carried out by the prime contractor responsible for the development of the experimental hardware.

Overall, the selection process must be fair and as open as possible to the various utilities. The responsibilities of the host utility must be clearly defined, and the experiment itself should be designed and implemented so that it becomes a dependable and contributing element in the host system.

3.6 SMALL UTILITY PLANNING AND SOLAR COMMERCIALIZATION

Utility planners are currently making load forecasts and equipment purchase planning projections for five to fifteen years in the future. Small solar thermal electric generating systems may be feasible and available by the latter portion of that planning period. However, only proven technologies are being seriously considered in today's decisions. Therefore, an important aspect of solar power development is the maturation of a self-sustaining solar industry. The transfer of such a new, unproven, highly sophisticated technology from the realm of research and development, into a commercialized technology, is an expensive and complex task. Commercialization efforts must proceed as quickly as possible so that solar equipment will actually begin to be considered in the utility planning decisions and, subsequently, penetrate utility power-generating systems. The participants at the workshop identified some of the major barriers and considerations in the commercialization of solar thermal electric power technology.

It appears that unestablished cost-effectiveness and financial risk due to unproven system reliability are the main barriers to commercialization. Therefore, issues should be addressed in two major areas:

- State-of-the-art for solar technology, plant operation and maintenance, and equipment reliability
- Availability to the utilities of risk-sharing opportunities and economic incentives for solar development and implementation.

The technological developments necessary to make solar thermal power systems viable are possible and can be accomplished with federal support, such as financial incentives. In addition, the participation of private industry in the development process should be encouraged in order to speed transfer of the technology to the private sector.

A number of specific questions must be addressed when planning for solar electric power generation:

- What are the projected costs of solar equipment ownership and operation?
- What is an acceptable level of risk for the various types of utility companies?
- How can barriers to utility involvement and participation be reduced?
- What is the most cost-effective size and timing for experimental demonstration projects?
- To what extent does the success of the experiments and demonstrations depend on cost- and risk-sharing and economic incentives for the utility industry?

To determine the answers to these questions, the roles of the Federal Government, the utilities, equipment manufacturers and user industries in the commercialization process must be more clearly defined. Specifically, the federal role should be to advance technology development; however, the government should not become the main driving force in commercialization and market development. Worthwhile federal incentives supporting the adoption of solar thermal technology may include:

- Research, development and demonstration funding
- Loan guarantees
- Interest and/or operation and maintenance subsidies
- Sell-back or lease-option-to-buy arrangements for experimental equipment
- Tax incentives such as special investment credits.

3.7 QUESTIONNAIRE

At the conclusion of the workshop, the participants were surveyed to solicit their evaluation of the workshop, itself. The results indicated that all of those in attendance benefitted from their participation. The major benefits that were reported included:

- An understanding of the purpose, goals and plans of the Small Power Systems Applications Program
- A better understanding of the state-of-the-art of solar thermal power technology
- An opportunity to influence solar power development through an ongoing participation in the program.

The workshop was viewed as successful and productive by nearly all of the individuals involved. It opened a communication channel between Jet Propulsion Laboratory and the utility community, as well as aided in the initial definition of requirements. Nearly all of the participants indicated a desire to have further involvement with the Small Power Systems Program through a variety of means, according to the needs of the developing program.

The Jet Propulsion Laboratory would like to publicly acknowledge the workshop participants for their helpful support of the Small Power Systems Applications Program. Aided by continued communication and involvement with the utility community, the Jet Propulsion Laboratory expects to provide a viable energy alternative for the future in solar thermal electric power generating technology.

Roster 4.0

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